

# Analytics Collaboration Project: *Demonstrating the Power of Collaboration to Solve Video Analytics Challenges in Baltimore CitiWatch*

PSCR Annual Stakeholder Meeting  
July 11, 2019

John Garofolo, Panel Chair

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and PSCR Analytics Portfolio Lead  
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#PSCR2019

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# Panel Agenda and Speakers

Unique Collaboration Integrating PSCR Research to Build  
Real-time Custom Video Analytic Capabilities and Testing Framework inside Baltimore CitiWatch



**John Garofolo** (Panel Chair) -- Analytics Portfolio Lead, NIST PSCR Program



**Major Samuel Hood** -- Director, Baltimore Maryland CitiWatch/  
Baltimore PD



**Julie Stroup** -- Public Safety Video Program Manager, City of Houston  
Mayor's Office of Public Safety and Homeland Security (PSIAP grant  
recipient under University of Houston)



**James Horan** – Project lead, NIST PSCR Analytics Container  
Environment Project



**Jason Corso** – CEO, Voxel51 Video Analytics (PSIAP grant recipient)

# PSCR Analytics Portfolio Strategy

## *Overarching Goal*

**Focus:** increasing automation to



**identify and analyze emergency events and conditions**



**in real-time**



**from a large number of data streams and**



**provide first responders with actionable information.**

*Project aligns with overarching goal of strategy*

# PSCR Analytics Portfolio Development Approach

*Multi-faceted to support critical R&D needs*



**Foster research and innovation** in key fundamental technologies



Create **data, tools/frameworks, and academic challenges** to lower barriers of entry, focus R&D, and increase research base



Support the **development of applied technologies** in providing at-scale real-time assistance to first responders



**Build interest/critical mass in R&D community** and **public safety involvement**



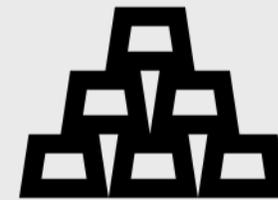
Implement **progressive application-focused analytic challenges** to bring communities and technologies together in novel/innovative ways



**Lay the foundations for future R&D and standards** development in integrated real-time analytic technologies

# Goal and Objectives of the Collaboration

*Demonstrate Agile Development/Testing of Video Analytics in Public Safety Environment*



Analyze  
the  
Infrastructure

*University of Houston/  
Houston PS Video Program*

Understand  
the  
Analytic  
Needs

*Baltimore CitiWatch*

Curate  
the  
Analytic  
Modeling  
Data

*Baltimore CitiWatch/  
Voxel51*

Build  
the  
Analytic Tools  
and  
Models

*Voxel51*

Refine  
and  
Test  
Models  
in  
the Lab

*Voxel51*

Integrate  
Within  
Measurement  
Framework

*NIST ACE*

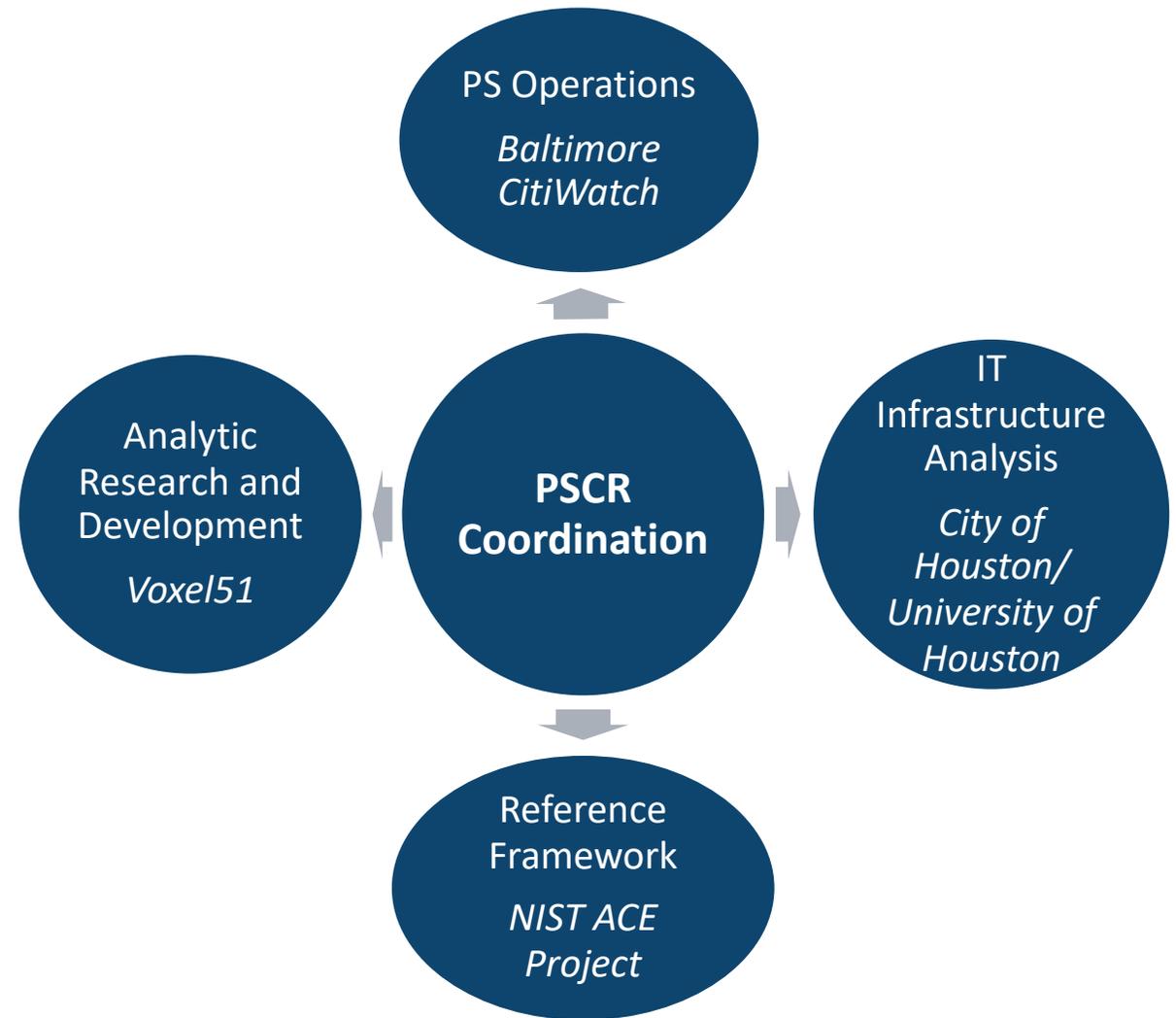
Test with  
Public Safety  
Users

*Baltimore CitiWatch*

Iterate and Document Best Practices

# Collaboration brings together several aspects of the Analytics Portfolio

- Foster multidisciplinary collaboration
- Develop process for public safety/research partnerships
- Understand the challenges of research and operations
- Create solution paths for real needs
- Develop best practices



# Lessons learned

- Understand
  - Current analytic practices, challenges, and drivers and map to technology capabilities
  - IT infrastructure and quantitative impact on analytics
  - Individual and intersectional policies
  - The data
- Create essential framework and building blocks to enable agility and measurement
- Crawl before you run
  - Multiple iterations on properly collecting and curating the data will be critically important to success in utilizing analytics – understanding the data content AND quality issues is key
  - Begin with easier analytic challenges and expand
  - Develop organic interfaces as you learn

# Next Steps

- Complete user testing on archival data
- Refine tools and test with real-time operational data streams
- Develop best practices paper

# Major Samuel Hood

Director of Operations, Baltimore CitiWatch Real-time Public Safety Video Monitoring Center



Saving Lives and Property in Baltimore MD with live video monitoring and coordination with first responders, Baltimore Homeland Security, and state and federal agencies

# Video Analytics Collaboration Project

## CitiWatch Baltimore, Maryland

- With a population of 620,961, the City of Baltimore is the largest independent city in the United States and the largest city and cultural center of the state of Maryland.
- It is known as a colorful, diverse city and is the economic hub of Maryland. Baltimore is famous for its beautiful Inner harbor; distinct neighborhoods; unique museums and the world-renowned Johns Hopkins Hospital to the east and the University of Maryland Medical Center to the west.
- Once a major industrial town, with an economic base focused on steel processing, shipping, auto manufacturing, and transportation, the city has transformed itself into a modern service economy providing a growing financial, business, and health service base for the Mid-Atlantic region.



# Video Analytics Collaboration Project CitiWatch Baltimore, Maryland

Baltimore “CitiWatch” is a ground-breaking *public safety and services center* focused on monitoring video from hundreds of cameras in public spaces around Baltimore City using retired and disabled public safety personnel to assist Law Enforcement, Firefighters, and Emergency Medical Services in responding effectively to all manner of emergencies.



# Video Analytics Challenges in Baltimore CitiWatch

## What the needs are

- Baltimore CitiWatch to understand the challenges associated with the development and use of advanced **video analytic technologies** in supporting improved detection and response to emergencies, and to work with the diversity of stakeholders in developing tools, metrics, and best practices towards improving and effectively leveraging these emerging technologies.



# Video Analytics Challenges in Baltimore CitiWatch

## How Video Analytics can help

- Video analytics will provide a force multiplier ability for proactive enforcement of public safety & services
- Need video analytics to provide first alert for monitoring staff that otherwise would be cost prohibited  
(human eyes cannot be everywhere, all the time)
- Video analytics leveraging the state-of-the-art in AI to detect emergencies of all kinds and support proactive response and forensic investigations



# Video Analytics Challenges in Baltimore CitiWatch

## How we created the Collaboration

Area(s) of expertise sought from across Federal, State, Local, and Private  
Principal Stakeholders:

Federal expertise NIST Video Analytics Public Safety Chair John Garofolo

Federal expertise NIST PSCR Analytics Framework Lead James Horan

City Municipality expertise Information Technology Julie Stroup

Private Video Analytics expert PSCR PSIAP recipient Jason Corso

City Municipality expert in video public safety operations Major Sam Hood



# Video Analytics Challenges in Baltimore CitiWatch

## The Importance of the Collaboration

- NIST (PSCR) Public Safety Innovation Accelerator Program (PSIAP) funding to support research in emerging video analytic technologies that are critically-needed in public safety.
- Knowledge sharing and close collaboration between researchers and public safety experts are essential to the effective development and acceleration of video analytics in public safety communications applications.



# Video Analytics Collaboration Project CitiWatch Baltimore, Maryland



# Video Analytics Collaboration Project in Baltimore CitiWatch

Major Samuel Hood III  
Baltimore Police Department  
Director of Law Enforcement Operations  
CitiWatch – Watchcenter  
Keeping Baltimore Safe  
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Fax: 410-962-7636



# Julie Stroup

Manager, City of Houston Public Safety Video Program - Mayor's Office of Public Safety and Homeland Security



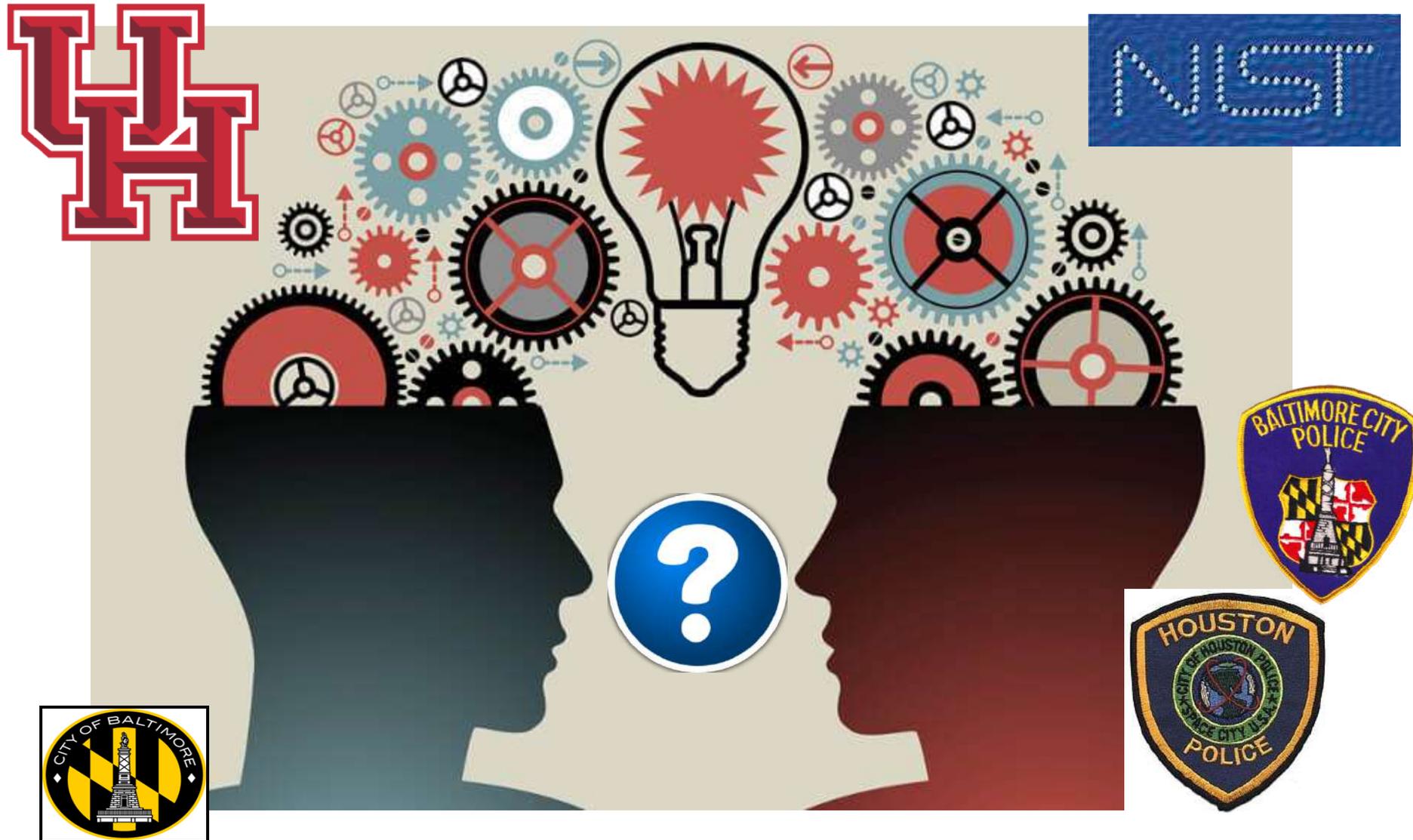
Providing real-time public safety video infrastructure and services to the City of Houston, TX and infrastructure analysis for Baltimore CitiWatch

Representing NIST PSCR PSIAP 2017 Grant Recipient Project:  
*Multi-tiered Video Analytics for Abnormality Detection and Alerting to Improve Response*

*Time for First Responder Communications and Operations*

University of Houston  
Grant 60NANB17D178

# Houston – Baltimore Sister City Relationship Enhanced by NIST Research Programs



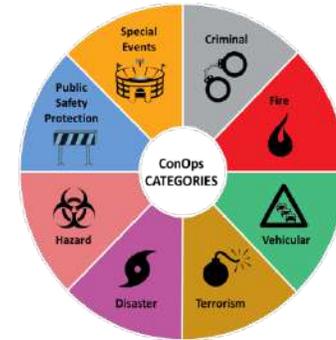


# Is Video Surveillance Infrastructure Ready for Video Analytics?



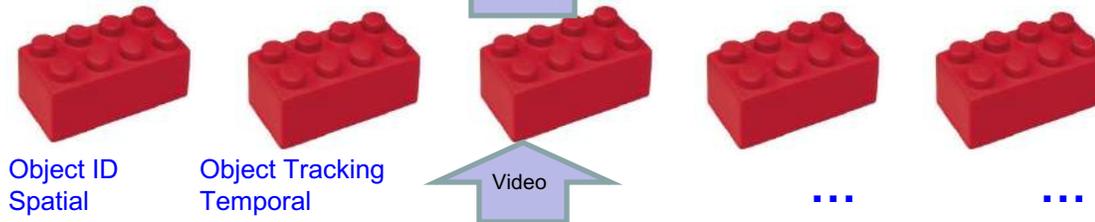
Public Safety Video  
VMS / PSIM USER

**PSIM infrastructure**  
Vidsys



**Enhanced Analytics Layer**  
Low / Mid / High Tier

**Basic Functional Modules**



Recorded Video      Live Video



Video Management System



Video encoding impact:

- Compression
- Resolution
- Frame Rate



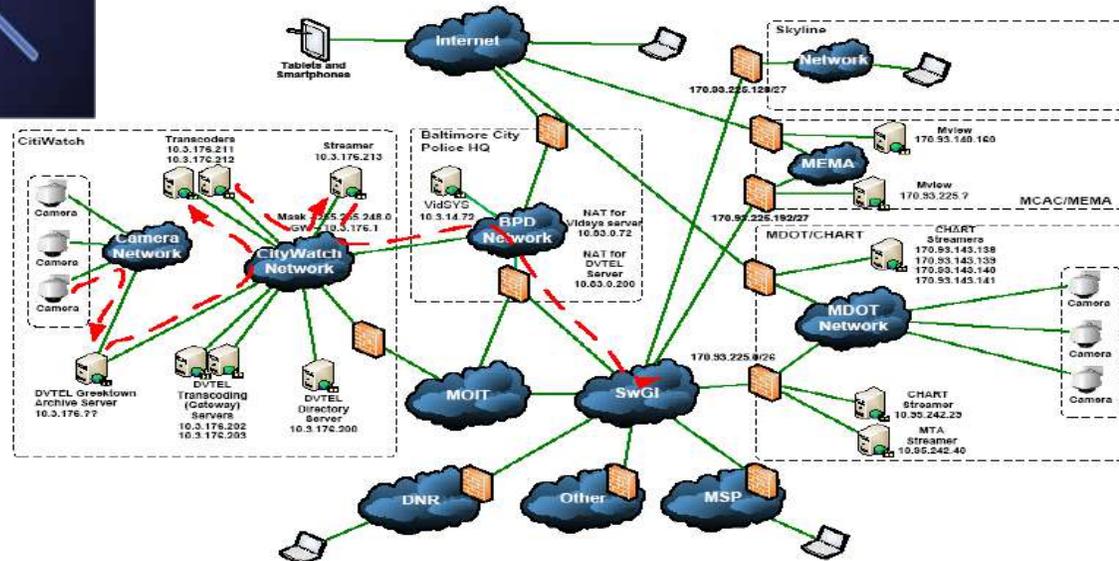
Communication Channel & Network Infrastructure impact:

- Packet loss
- Network Congestion
- Unexplained Interference

# Houston & Baltimore Complex Network Architectures



Regional Sharing Architecture - 2 10 2014 - Streaming Flow 2



# Open CSIM Platform



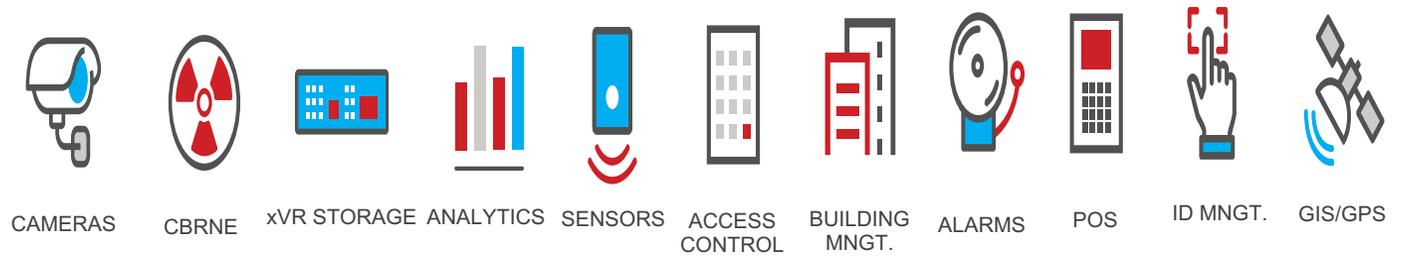
## Convergence Applications

- 3D Mapping
- CAD
- Compliance Reporting
- IT Security Management
- Risk Management

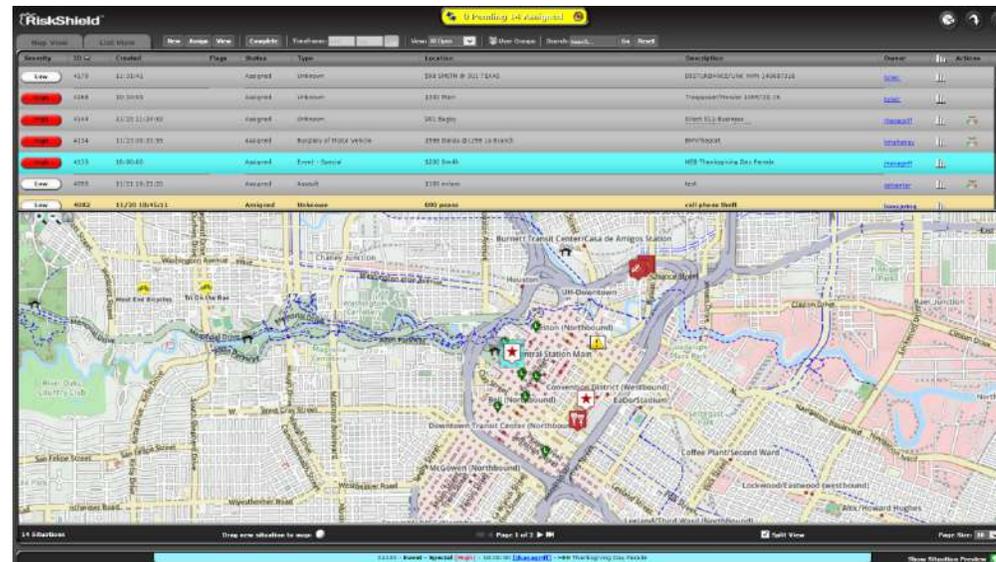
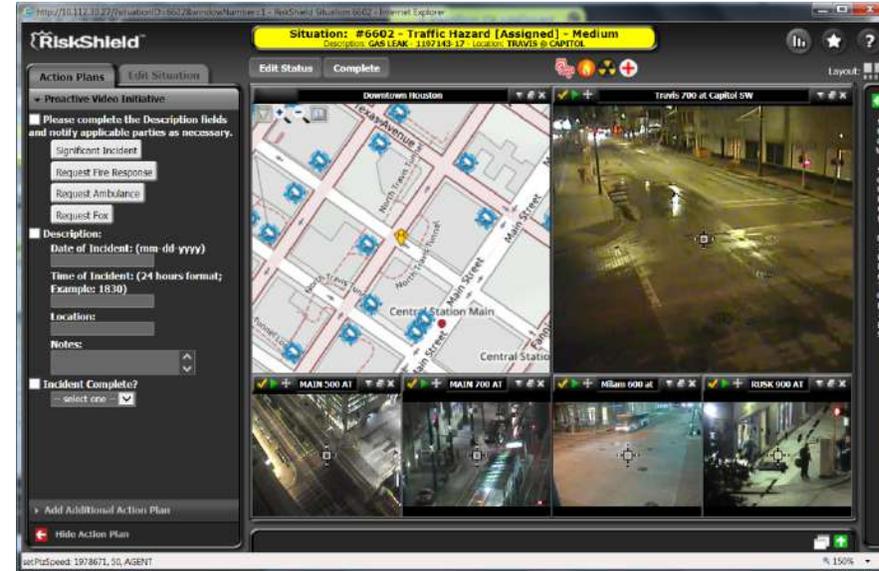
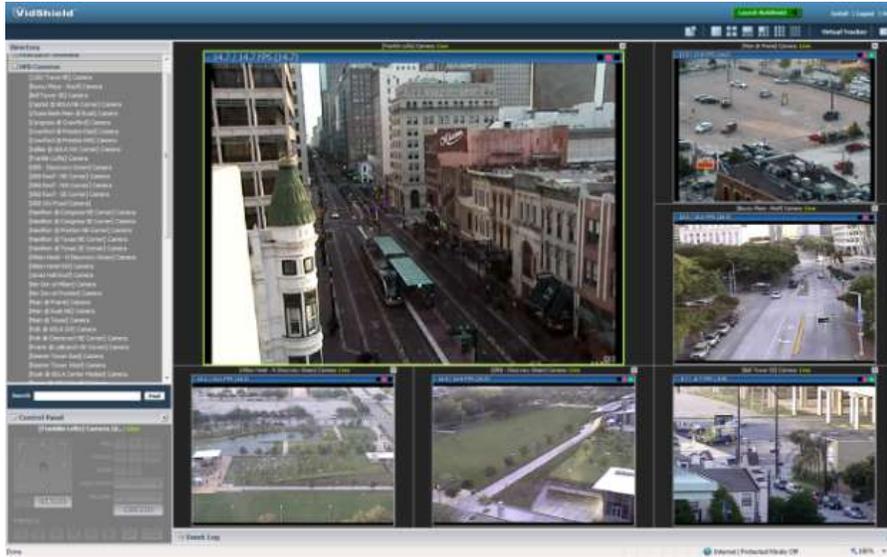


## Incident Management + Related Actions

- Communications
- Device Management
- Document Mngt.
- Mass Notification
- System Management



# Houston Public Safety Video Situational Awareness & Common Operating Picture





# Baltimore Public Safety Video Situational Awareness & Common Operating Picture

**RiskShield**  
Situation #396 Gunshot Detected [Pending] High  
Description: Suspicious Gunshot Detected - Location: E St. & Bolton South Boston

**Gunshot Detected Action Plan**

- Establish Audio Contact with Emergency Responders
- Call Police
- Review Live Video from Report Location to Monitor Situation
- Do you see suspicious activity?
- Do you see suspects with guns?
- Do you see anyone that appears to be shot?
- How many people appear shot?
- What direction did suspects travel?
- Describe mode of transportation (on foot, make/model of vehicle, etc.)?
- Description of suspect(s)  
Caller Sex: select one
- Race of Suspects
- Age of suspects
- Approximate heights
- Additional descriptions
- Remarks

Time | Type | Source | Description



**vidsys** Pending 100 - Assigned 0

Severity	ID	Created	Flags	Status	Type	Location	Description	Owner	Actions
High	473358	14:21:23		Pending	CAD	36 S PACA ST	Code=28 :: ATT SUICIDE @ 36 S PACA ST	*Unassigned*	
Medium	473357	14:25:57	▲	Pending	CAD	501 E 33RD ST	Code=61 :: WANTED ON WARR @ 501 E 33RD ST it...	*Unassigned*	
Medium	473356	14:25:48		Pending	CAD	3300 N EDGEWOOD ST	Code=FI :: FIELD INTERVIEW @ 3300 N EDGEWOOD...	*Unassigned*	
Medium	473355	14:25:18	▲	Pending	CAD	GLYNDON AV/S CARLY ST	Code=87 :: NARCOTICS @ GLYNDON AV/S CARLY S...	*Unassigned*	

100 Situations | Drag new situation to map: | Page 1 of 10 | Split View | Page Size: 10 | Show Situation Preview



# UH/COH Team Findings - Baltimore Site Visits

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## **Automatic touring:**

Reduces video compression efficiency and requires a higher bit-rate for transmission. Without sufficient bandwidth, the video quality is further reduced and visibly affected.

## **Camera resolution, bandwidth, and frame rate:**

The majority of the cameras are set to high resolution and frame rate while bandwidth is capped very low. The compression of video required to transmit with the cap in place results in poor video quality.

## **Transmission & camera configuration – Wired, wireless:**

The majority of the cameras deployed are using wireless connectivity to route the video data back to main system. If not configured correctly (fiber network, cameras and radios) this could result in contention and loss of video data packets.

# Dr. Jason Corso

CEO, Voxel51 Video Analytics



Performing research and developing tools and systems to enable agile development and customization of video analytics for public safety

Representing NIST PSCR PSIAP 2017 Grant Recipient Project:

*ETA: Extensible Toolkit for Analytics in Public Safety*

Voxel51

Grant 60NANB17D159

# Voxel51 Baltimore Pilot Slides

Dr. Jason Corso  
NIST PSIAP Grant Results



[jason@voxel51.com](mailto:jason@voxel51.com)

vehicle density: light  
road: urban  
scene: four way intersection

# Voxel51

## Extracts Valuable Insights in Video

VEHICLE 37

van, GMC

VEHICLE 35

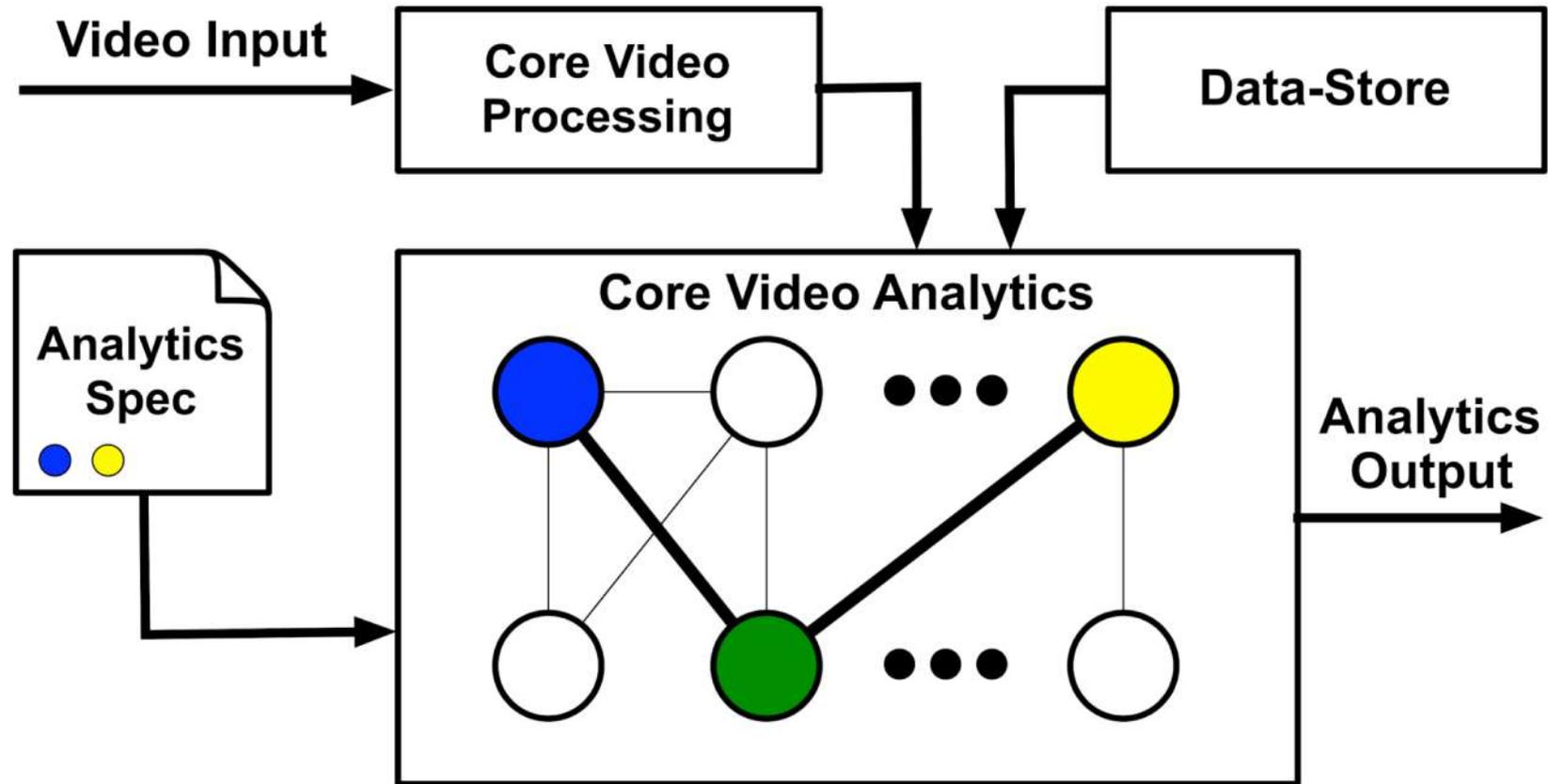
suv, yellow

VEHICLE 38

sedan, black

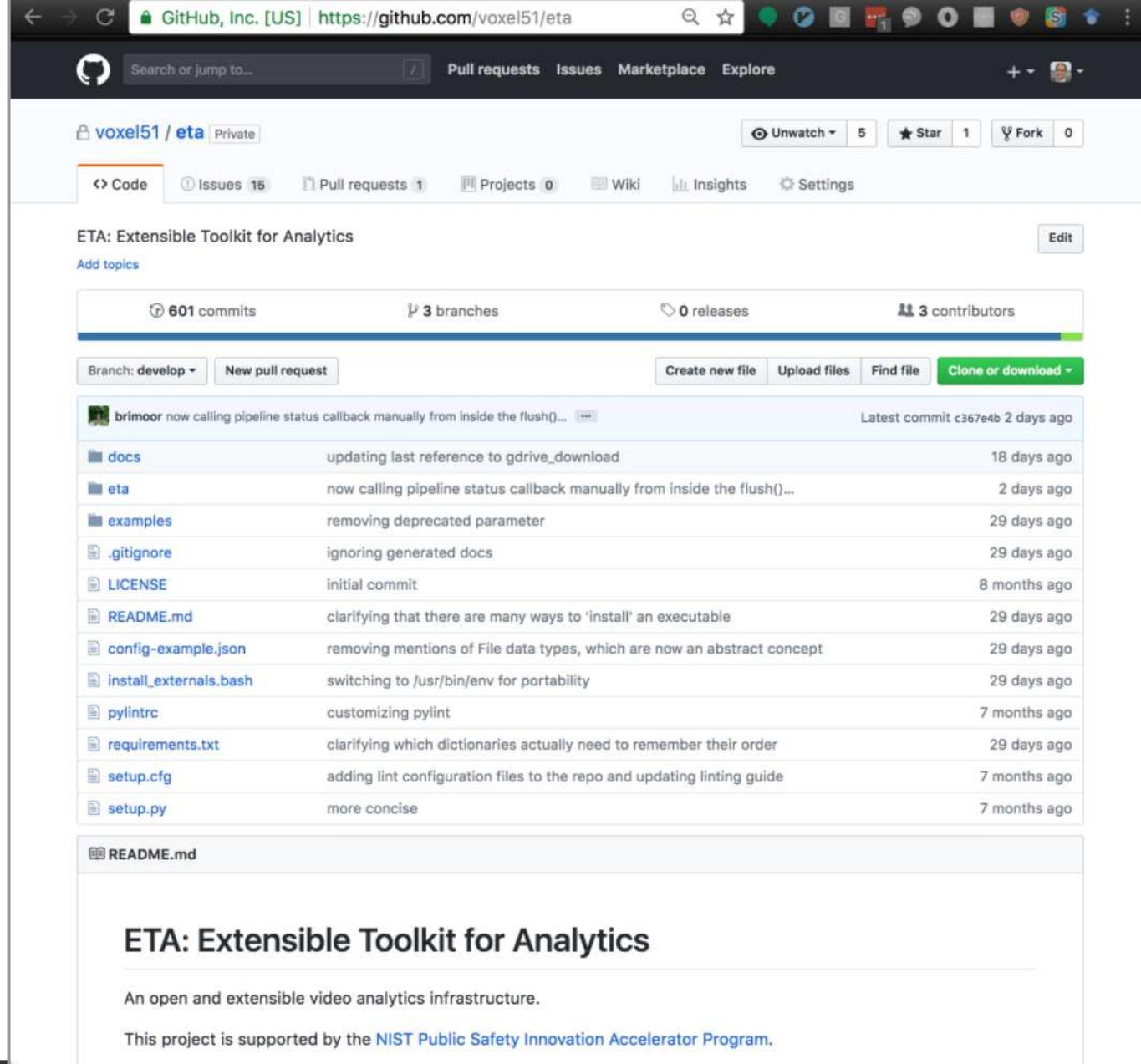
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# Core Video / Analytics Connectivity – ETA Project



# Open-Source

- ETA – Vision Engine Code
- API-PY – Python API Client Library
- API-JS – Javascript API Client Lib.
- Platform-SDK – Wrap your custom vision methods to be deployed on the platform at scale.
  
- Coming Soon!
  - Player51 – State of the art Javascript video player
  
- All at <https://github.com/voxel51>



GitHub, Inc. [US] <https://github.com/voxel51/eta>

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ETA: Extensible Toolkit for Analytics Edit

Add topics

601 commits 3 branches 0 releases 3 contributors

Branch: develop New pull request Create new file Upload files Find file Clone or download

brimoor	now calling pipeline status callback manually from inside the flush()...	Latest commit c367e4b 2 days ago
docs	updating last reference to gdrive_download	18 days ago
eta	now calling pipeline status callback manually from inside the flush()...	2 days ago
examples	removing deprecated parameter	29 days ago
.gitignore	ignoring generated docs	29 days ago
LICENSE	initial commit	8 months ago
README.md	clarifying that there are many ways to 'install' an executable	29 days ago
config-example.json	removing mentions of File data types, which are now an abstract concept	29 days ago
installexternals.bash	switching to /usr/bin/env for portability	29 days ago
pylintrc	customizing pylint	7 months ago
requirements.txt	clarifying which dictionaries actually need to remember their order	29 days ago
setup.cfg	adding lint configuration files to the repo and updating linting guide	7 months ago
setup.py	more concise	7 months ago

README.md

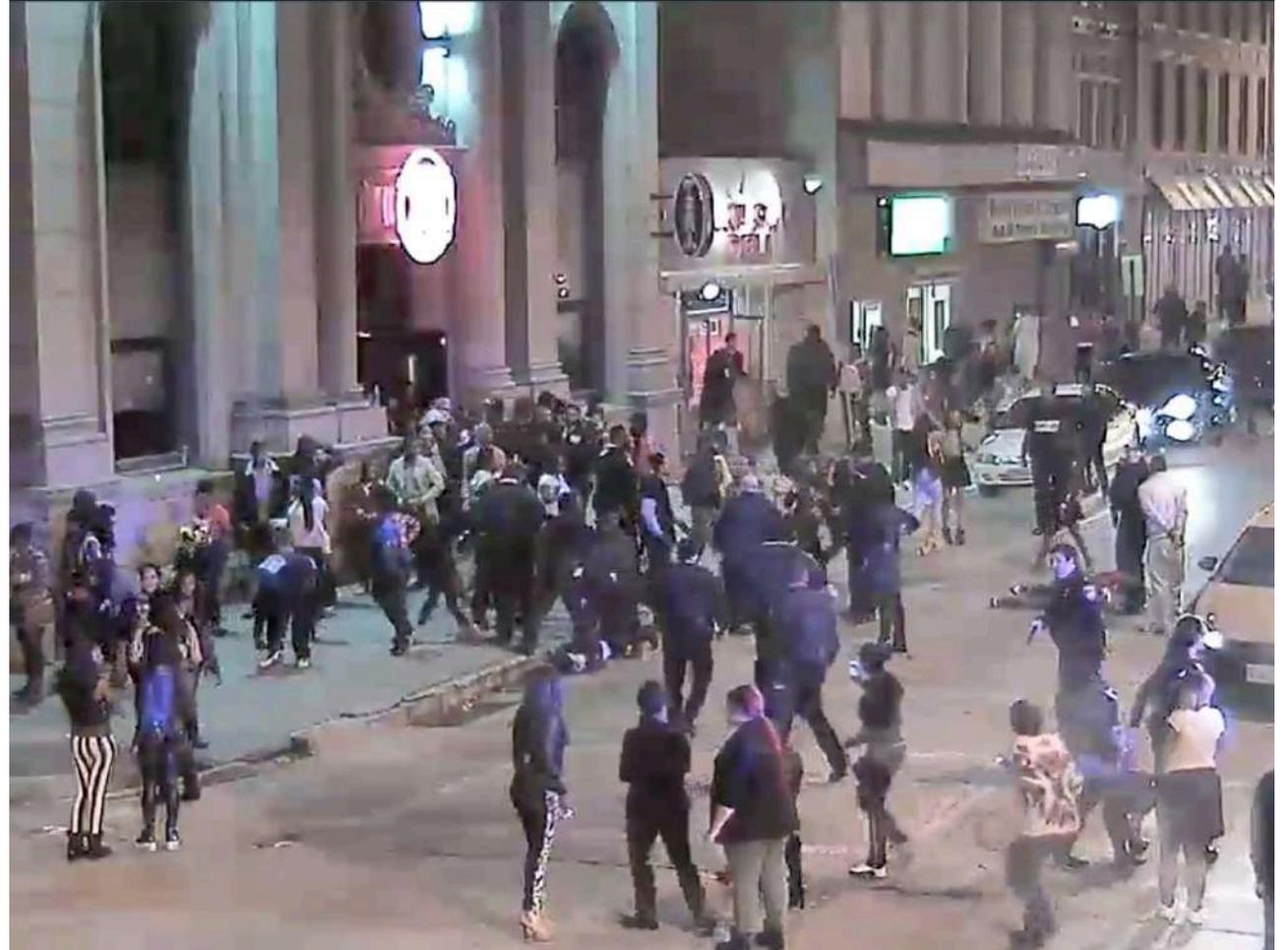
## ETA: Extensible Toolkit for Analytics

An open and extensible video analytics infrastructure.

This project is supported by the [NIST Public Safety Innovation Accelerator Program](#).

# Challenge in Public Safety

- Use this information
  - Rapidly
  - To keep people safe
  - To detect situations where first responders are needed
- Constraints
  - Ton of video
  - Streaming
  - What to look at?
  - What to respond to?



# Focus of Pilot

- Detection of events that we want to respond to
  - A fight may be starting
  - A person falls
- Specific labels we emphasized were
  - Fire
  - Fall Down
  - Knock Down
  - Fight
  - Punch



# Focus and Procedure

1. Train a core analytic model
  - Use large scale, public datasets to initialize training.
2. Work with site (Baltimore) to refine analytic model
  - Gather site-specific data
  - Annotate it
3. Refine model with site-specific data
4. Deploy

Type	#Videos	Duration	Size
All Site-Specific	682	1.8 Days	35.5GB
Relevant Clips	233	12.1 Hours	10.4GB

# Examples

Visual interface to explore the various events of interest.

Here is an example showing either knock-down, punch, fall-down, or exchange-object cases in a small study set.

The interface displays surveillance data for 'baltimore pilot surveillance data'. It features a sidebar with filters for 'Person' and 'Action', including 'Knock Down', 'Punch', 'Fall Down', and 'Exchange Object'. The main area shows a summary of 10 Videos, 25 Clips, 6.1K Frames, and 3.5 min Total Duration. A 'Statistics' section shows counts for 'ACTION' (67) and 'BEHAVIOR' (71). The 'Matching Clips' section displays a grid of 10 video thumbnails.

Category	Item	Count
ACTION (67)	Exchange Object	44
	Punch	15
	Hug	2
	Smoking	2
	Knock Down	1
	Fall Down	1
	Kick	1
	Finger Point	1
	Handshake	0
	Enter Car	0
	Talking Into Car Window	0
	Handling Gun	0
	Wave	0
	Sit	0
Exit Car	0	
Lay Down	0	
BEHAVIOR (71)	Normal	44
	In Fight	25
	In Argument	2



[solutions@voxel51.com](mailto:solutions@voxel51.com)  
<https://voxel51.com/>

# James Horan

Project Lead, NIST PSCR Analytics Container Environment Project

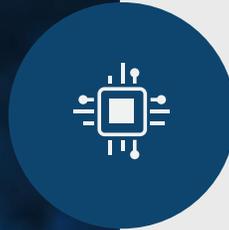


Creating extensible reference framework for test and measurement of at-scale analytics for public safety

# PSCR Public Safety Analytics

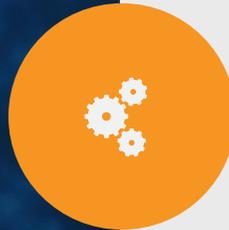
Analytics Container Environment (ACE)

**PULLING  
THE FUTURE  
FORWARD**



## System

- The Analytics Container Environment (ACE) was developed as an adaptable modular reference framework system



## Software

- ACE hosts analytic functions and software systems for research, development and testing



## Network

- ACE is designed to work in the Public Safety network environment as well as the lab

# PSCR Public Safety Analytics

ACE – As a Tool Kit



## Analytic Testing

Using ACE modules to measure the performance of machine learning algorithms with public safety data

## Advanced Analytic System

Flexible ACE 'module' will run in multiple computer environments without having to customize systems and software.



# PSCR Public Safety Analytics

ACE- Machine Learning 101



## Machine Learning

Algorithms are very powerful, but need huge quantities of accurate data to learn



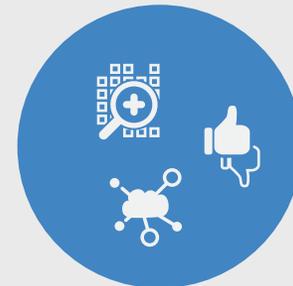
## Training Data

Algorithms are often trained on 'found' data which do not accurately depict real Public Safety situations



## Real World

Systems will typically work great in the lab, but perform poorly when you use real world data



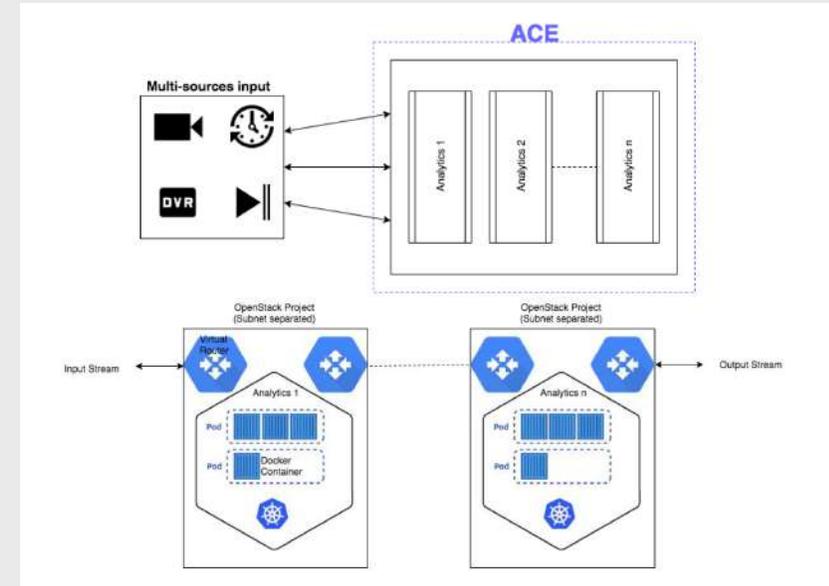
## Data Quality

Real world data is usually very hard to capture, clean and use for research purposes

# PSCR Public Safety Analytics

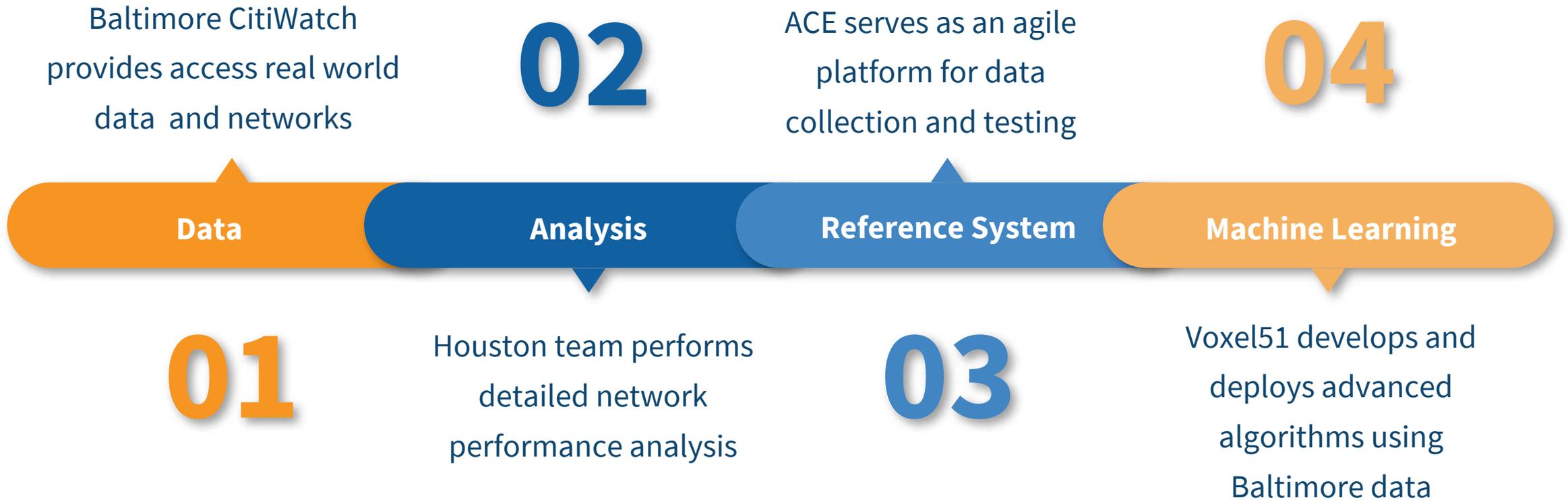
## ACE – In a Public Safety Environment

- Instead of having the system in the lab, we move it into Public Safety space
- Measurement and testing can be done on live or locally stored data from *real* Public Safety sensors and sources
- Now we can train our machine learning systems on real data which should result in improved real-world system performance
- Flexible architecture can scale to public safety infrastructure



# PSCR Public Safety Analytics

ACE – Baltimore Collaboration



# PSCR Public Safety Analytics

ACE – Baltimore Collaboration



## Integration

Integrating ACE to co-exist within CitiWatch infrastructure to perform analytic test and measurement using CitiWatch data. Houston team provides network information optimizing video data quality and maximizing analytic performance. Voxel51 deploys cutting-edge algorithms to analyze actual public safety data.



## Next Steps

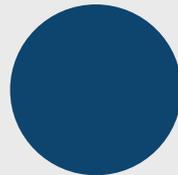
Continue to coordinate with Voxel51 (advanced analytics) and University of Houston (network performance analysis) in a team-based approach to optimize analytic performance working towards analyzing live streams to provide alerting for CitiWatch. Expand collaboration. Share ACE as open development resource with AI/ML community.

# Contact Us

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(301) 975-4238

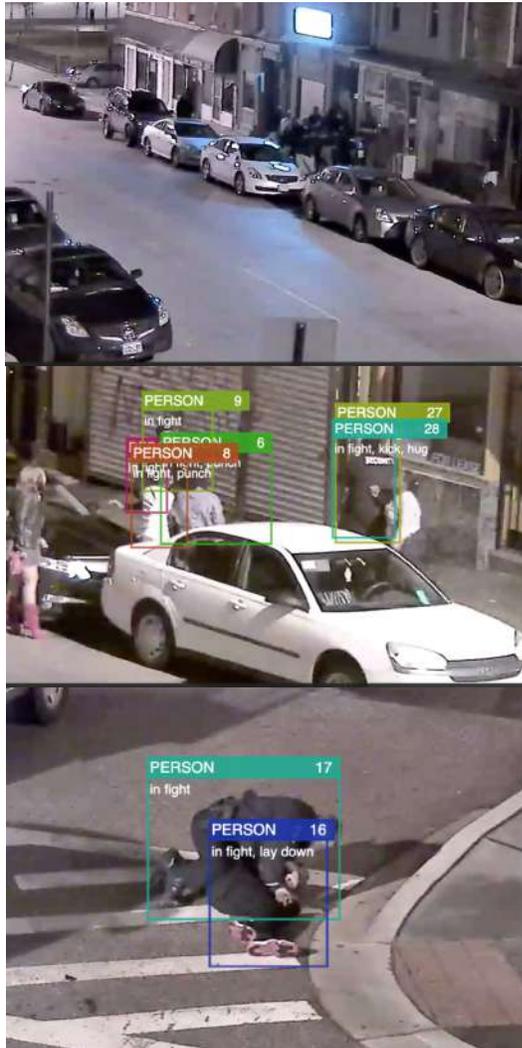


# Demonstration

Dr. Jason Corso, Voxel51



Early capabilities created in the collaboration within 6 months!



Video a78c1b20

Starts at 00:00:13.6

Duration: 9.4s

Reset Clip



# Questions?



#PSCR2019

Break for  
**Lunch**  
BACK AT  
**1:00PM**